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HIGH-FREQUENCY EQUIPMENT OF RADIO-RELAY COMMUNICATION LINES

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Herein, equipment is described that is designed for main line radio relay communications with frequency packing.

Designation of the Equipment

The equipment for radio-relay communication lines provides a duplex wide-band channel which is packed by means of the equipment of terminal stations of system K-24 to get 24 high-frequency telephone channels on one line. Apart from K-24 equipment, terminal apparatus of other types can also be employed for packing, if the range of its working frequencies is disposed in the band of the linear spectrum of the working frequencies of the K-24 equipment (12 to 108 kc).

Radio relay lines outfitted with the given equipment coordinate very well with the general system of cable communications, since their junction with the cable lines can be made directly in the group line without transduction in a lower frequency.

In its technical ratings the equipment provides high-quality telephone channels corresponding to the standards and recommendations of MKKF for channels of high-frequency cable lines of communication.

In addition to the 24 telephone channels, there is a separate channel for service communications of the line's operating personnel. Provided to increase the stability of communications is an automatic spare for each set of equipment at all points of the line.

The equipment of the radio relay line is assembled from the apparatus of terminal and intermediate stations.

Shown in Figure 1 is a simplified block-diagram of the construction of a radio relay line that consists of 2 terminal and a number of intermediate stations. Located at the terminal stations are the terminal packing equipment (K-24) and the receiving-transmitting radio set of the terminal stations (OS). At the intermediate stations only the receiving-transmitting radio set of intermediate stations (PS) is installed. The intermediate points of the line at which separation of parts of the telephone channels is required, are called the chief stations of the line. They are equipped with the receiving-transmitting radio set of terminal stations (OS) and with the special set for separation of part of the telephone channels (AV).

Equipment of a Terminal Station

Figure 2 shows the block-diagram of the receiving-transmitting radio set of a terminal station. The currents of all channels from the output of the group amplifier of the transmission of terminal equipment K-24 enter the input of the radio set and through extender U are supplied to the coordinating device SU. To this same coordinating device are supplied the talking currents from the talk-call device PVU of the service channel and the current of the control frequency from the generator of the control frequency GKCh. Frequency modulation is employed in the transmitter. The summary current of all channels, including the service channel and the current of the control frequency, enters the reactive tube of the frequency modulated generator of intermediate frequency ChMG. The modulated oscillations of intermediate frequency are amplified by amplifier $UPCh_2$ and are delivered to the power mixer SM_3 to which are also supplied the oscillations of superhigh-frequency from the driver generator ZG. Separated at the output of the mixer are the oscillations of the difference or summary frequency which enter the transmitting antenna. The transfer is thus accomplished of the spectrum of frequency modulated oscillations from the range of intermediate frequencies to the range of working frequencies.

At the output of the transmitter there is a power monitor ZM, readings of which are proportional to the power returned by the transmitter to the antenna.

The reply signal received by the receiving antenna enters the input filter VF of the reception device, and after that to the crystal mixer SM_1 to which are supplied also the oscillations of superhigh-frequency from heterodyne G. The oscillations of intermediate frequency formed in the mixer are amplified by amplifier $UPCh_1$ and after limitation in amplitude enter the frequency detector ChD. Demodulation of the received signal is accomplished in the frequency detector and restoration of the currents of all channels to their original spectrum of frequencies.

From the output of the frequency detector the currents of all channels, including the current of the service channel and the current of the control frequency, are supplied to the filters F_1 and F_2 which separate the working and the service channels. Filter F_1 contributes large attenuation to the talking frequencies of the service channel and passes to the input of the group amplifier of reception GU, the currents of the working channels, and also the current of the control frequency. At the output of this amplifier is connected filter F_3 which creates a big attenuation for the current of the control frequency. Thus, from the output of filter F_3 to the output of the equipment goes only the currents of the working channels which occupy the band of frequencies of 12 to 108 kc. The level of these currents is the same as it is at the input of the equipment.

The output of the radio set is connected with the input of the group receiving line of the terminal equipment K-24, a group amplifier of reception K-24 not being used, since the remnant attenuation of the group channel of the radio set is equal to zero.

Filter F_2 passes the talking currents of the service channel and creates a big attenuation for the currents of the working channels and control frequency. From the output of this filter the talking currents of the service channel are supplied to the talk-call device PVU of the service communications.

From the output of the group amplifier GU the current of the control frequency goes to the receiver of control frequency PKCh, equipped with a level monitor. By means of this monitor it is possible to control constantly the level of the current of the control frequency at the output of the group line of the radio relay line or at separate segments of it, and since the level of this current at the input of the line is constant, the remnant attenuation of the group line is thereby controlled.

Since the frequency of oscillations generated by the transmitter is not stabilized, automatic trim of the heterodyne frequency is employed to maintain stable communications in the receiver. The device of automatic frequency trim APCh is switched into the output of the receiver's amplifier of intermediate frequency $UPCh_1$. It consists of a discriminator, a system of relays, and a little motor controlling an element of tuning the circuit of heterodyne G. Variations of transmitter frequency cause variations of receiver intermediate frequency. Due to this, voltage is formed at the output of the discriminator of APCh, the polarity of which depends on the sign of the variation of the intermediate frequency relative to its normal magnitude. This voltage across the system of relays switches in the little motor which changes the frequency of the heterodyne in such manner that the magnitude of the intermediate frequency remains constant and equal to the nominal value.

At the output of intermediate frequency amplifier $UPCh_1$, the indicator IN is connected, its reading being proportional to the signal voltage at the input of the receiver.

In the receiver there is an automatic regulator of amplification which protects the amplifier of intermediate frequency from overload when raising the level of the signal at the input.

Equipment of an Intermediate Station

The block-diagram of the receiving-transmitting radio set of an intermediate station is shown in Figure 3. The signal received by the receiving antenna enters the input filter VF of the receiver and after that goes to the crystal mixer SM_1, in which oscillations of intermediate frequency are formed in consequence of the interaction of the oscillations of the signal and of the heterodyne G. After amplification of these oscillations in the amplifier of intermediate frequency $UPCh_1$, they are delivered to the second mixer SM_2. Also delivered to it are oscillations from the second heterodyne $ChMG_2$. Oscillations of the second intermediate frequency, which are formed at the output of the second mixer, are amplified by the second amplifier of intermediate frequency $UPCh_2$ and go to the power mixer SM_3 which is excited by oscillations of superhigh-frequency that enter from driver generator ZG. At the output of the power mixer, oscillations of the difference or summary frequency are separated, going to the transmitting antenna. In the receiver, just as in the equipment of the terminal station, automatic trim of heterodyne frequency is employed.

It is evident from the diagram that elements for demodulation and modulation of the signal are absent in the main circuit of the intermediate station equipment. The intermediate station is only an amplifier with conversion of frequency. The exclusion of nonlinear elements (modulator and demodulator) from the main circuit of the station permits reducing the nonlinearity of the entire group channel of the radio relay line. For correction of nonlinear distortions caused by the nonlinearity of the phase characteristic of the intermediate station, a special circuit which equalizes the phase characteristic is included in the amplifier of intermediate frequency $UPCh_1$.

The separation of the talking currents of the service channel from the main station circuit is accomplished by means of frequency detector ChD, switched into the output of $UPCh_1$, and filter F_2. The lead into the main circuit of the service channel from the talk-call device PVU of the given station is done by means of modulating the frequency of the second heterodyne $ChMG_2$ with talking currents that enter the reactive tube of this generator from the talk-call device through the extender U.

Since the intermediate station is an amplifier, the disappearance of a signal at its input also causes the signal's disappearance at the output. Moreover, communication is lost not only along the working, but also along the service, channel. In order to retain communication along the service channel of the given station when the signal disappears at its input, an auxiliary generator VG is provided, switched into the input of the second mixer SM_2.

This generator generates oscillations having a frequency equal to the intermediate frequency of the receiving device. It is switched in by means of the indicator IN when the signal diappears at the output of the UPCh, and seemingly replaces the receiver by itself. Then the transmitting part of the station continues to operate, and conversation in the service channel can be transmitted from the given intermediate station toward the segment of communication line in the working order.

All the main blocks of radio equipment of the intermediate station are just the same as in the terminal station; i.e. both stations are unified to the maximum.

Service Communication

The equipment described provides one channel of service communication. Since this channel is general for all stations of the line, the conducting of service talks is difficult when their number is large. For facility of operation, the service channel is divided into sections enclosed between every 2 main stations or between a terminal station and the main station nearest to it. The service channel thus remains general only for the stations of one section, which makes it possible to carry on service conversations simultaneously on all sections without mutual interferences. Communication along the service channel between stations of different sections is accomplished by means of transit connection along this channel to the appropriate main stations.

The service channel which occupies the band of frequencies from 300 to 5000 cps is divided into 2 channels: properly the talk and call channels. Transmitted along the call channel are the voice frequencies for selective calling of the station. Generators of the voice frequency call are installed at each station of the line; therefore, from every station, any station of a given section can be called along the service channel. The connection of sections to one another in the service channel is done at the main stations either manually or automatically. Automatic transit connection of sections is accomplished by means of sending a special signal from any main or terminal station of the line. Thus, by means of a transit connection any station of the line can be called.

Foreseen in the equipment is the possibility of checking up on the main qualitative indexes of the line circuit without resort to the terminal packing equipment. For this purpose the equipment is supplied with a special measuring device, installed at the terminal and main stations of the line and controlling the voltage of noise in a special channel, the frequency band of which is outside the limits of the linear spectrum of the working channels. This same measuring device permits controlling the nonlinearity of the group circuit of the whole line or its sections.

Automatic Reservation

The equipment is supplied with a device of automatic reservation which is set in motion from the signal monitor IN of the receiver and

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the power monitor IM of the transmitter.

At every station of the line a working and a spare set of equipment are installed; the tubes of the spare sets receiving only a filament supply. When the signal fails in the receiver or at the output of the transmitter of the working set of equipment, a system of automatics is set in motion which switches in the supply of the spare set and switches over the antenna from the basic set to the reserve by means of special antenna changeover switches.

When the signal fails in the receiver, the automatic system switches in at first only the spare receiver, and then, after the signal appears at its output, the reserve transmitter. Excluded, owing to this, is the possibility of false change-overs to spare sets at a given station in case of a breakdown at the preceding station of the line. The auxiliary generator VG at the intermediate station also serves this same purpose; it secures the dispatch of the signal to all succeeding stations when the signal fails at the input of the given station or when the receiver breaks down. Thereby it prevents false change-overs to spare sets at the succeeding stations.

Antenna System

A system consisting of a small horn antenna and 2 reflecting mirrors is employed in the capacity of the main type of antenna for the lines outfitted with the described equipment. A schematic drawing of such a system is shown in Figure 4. The small horn antenna RA is installed inside the premises in immediate proximity to the radio equipment and connected with the latter by a short segment of light type coaxial cable. The horn antenna irradiates the bottom elliptical mirror EZ, which is situated close to the tower and inclined to the horizon at an angle of 45°. The horn antenna, together with the elliptical mirror, forms a directional antenna with a high amplification factor, which irradiates the plane mirror PZ situated at the top of the tower. This mirror is also inclined to the horizon at an angle of 45° and serves for varying the direction of the ray. The advantage of such an antenna system is that long connecting feeders are not required; they introduce big losses and harmful reflections and are rather complicated in operation.

In those cases when the use of this system is for some reason impossible, e.g., when the station is placed in a big city or lofty towers are not required, the usual parabolical antenna with vibrator irradiator is used, being connected with the equipment by coaxial cables.

The separation of the lines of reception and transmission in one antenna system is accomplished through use of varied polarization.

Construction Design of Equipment

The equipment design is shaped in the form of cabinets with sliding panels. The receiving-transmitting radio set with its sources of supply is placed in one cabinet, and the talk-call device of service communication, the automatic and control device, and also the measuring instrument is put into another cabinet of the same size. The complete set of the equipment of an intermediate station, including 100% reserve, consists of 4 high-frequency cabinets (with receiving-transmitting radio equipment) and one control cabinet (with devices of automatic control and service communications). The set of equipment of a terminal station consists of 2 high-frequency cabinets and one control cabinet.

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Figure 5 shows the exterior view of the high-frequency cabinet of an intermediate station. Located in the upper part of the cabinet is the ventilator for cooling the high-frequency tubes of the transmitter, and on the front panel of this part are light signals that characterize the station operation, and a table of tuning. The lights report on normal equipment operation, its faults, and the absence of a signal from the preceding station, and also whether the given set is a working or spare one. Further, from the top down in sequence are placed the panel of the transmitter, the panel of the receiver, the panel of group devices and service communications, the cabinet switching-in table and 3 panels of rectifiers.

The equipment is supplied with signalling and a number of control devices which facilitate carrying on observation of its operation. By means of measuring instruments situated in the panels, it is possible to control the duty of all tubes, the presence of a signal in the receiver, and in the output of the transmitter. Alarm lights in the respective panels and the general emergency light in the cabinet's upper panel signal about any breakdown which is accompanied by the loss of the signal in the receiver or the transmitter. The switching-in of various voltages and the burning-out of safety fuses is also marked by appropriate signal lights. The equipment does not require the constant presence of service personnel. When there is need, for example, to talk over the service channel, the person on duty can be called into the equipment room by means of signalling provided in the set.

In external appearance the high-frequency cabinet of the terminal station does not differ from the cabinet of an intermediate station.

Shown in Figures 6 and 7 are photographs of the main panels of the high-frequency cabinet: the receiver panel (Figure 6) and the transmitter panel (Figure 7). The panels are equipped with cut-in contact valves for the connection of low-frequency circuits and supply circuits and with special high-frequency transitions for the connection of high-frequency circuits. The design of the panels of terminal and intermediate stations are identical.

The set is operated on single-phase alternating current at 50 cycle frequency and 220 v.

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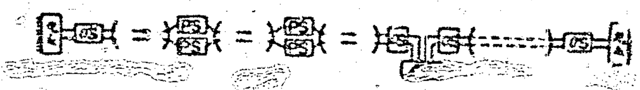

FIGURE 1

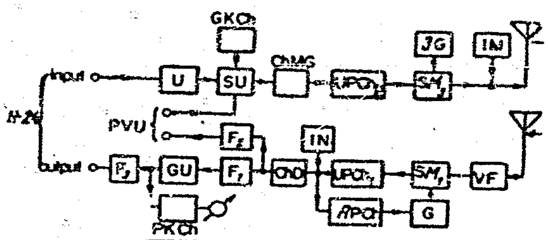

FIGURE 2

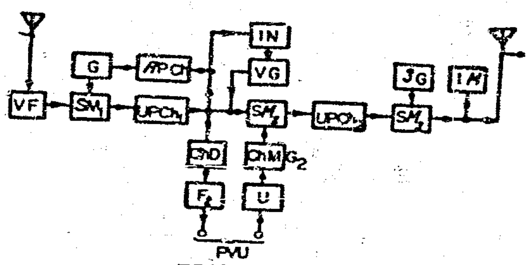

FIGURE 3

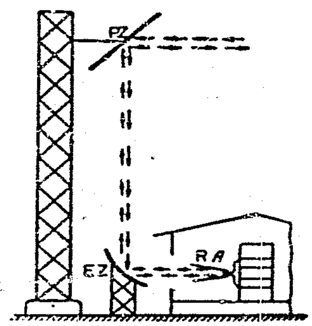

FIGURE 4

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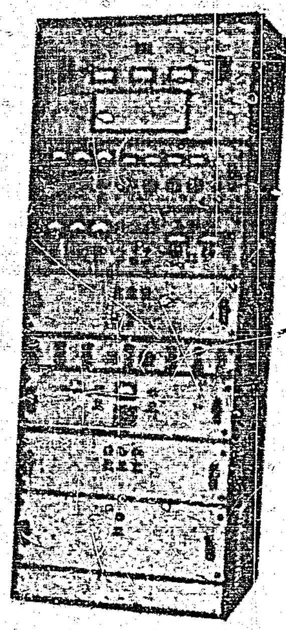

FIGURE 5

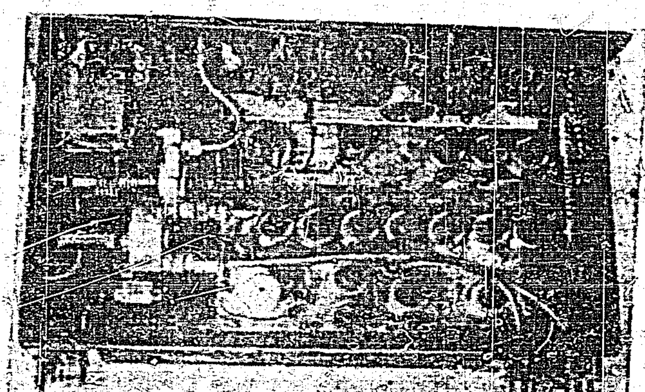

FIGURE 6

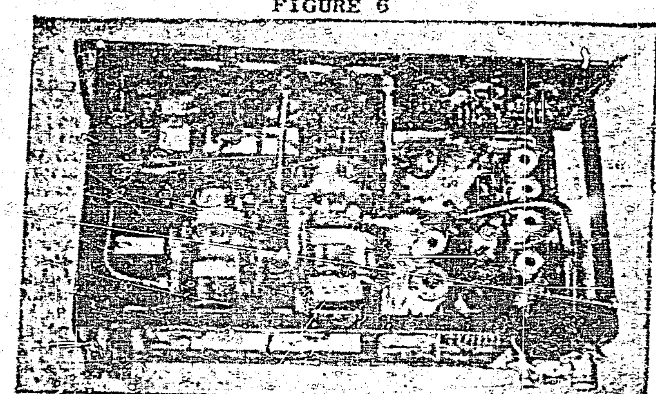

FIGURE 7

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